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NEW CONCEPTS IN SHIP DIRECTIONAL CONTROL,(U)

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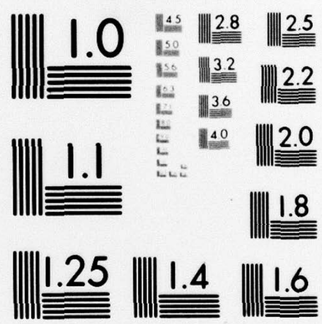


MICROCOPY RESOLUTION TEST CHART
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# NEW CONCEPTS IN SHIP DIRECTIONAL CONTROL

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# I. INTRODUCTION

A new propulsion system for ships has been discussed in Sheets (1978). This propulsion system provides a source of pressurized water between the pump and the turbine of the hydraulic transmission and generates a water jet leaving the transmission turbine. The water jet leaving the transmission turbine can be vectored by means of discharge vanes so that it is possible to greatly improve the directional controllability of ships. Several configurations are possible for the proposed control system, but at this time, only a single configuration is presented. The thrust force of the jet leaving the hydraulic transmission can be adjusted and modulated to meet requirements. For maximum ship control, the quantity of flow and power into the transmission can be increased compared to power transmitted to the propeller. This new control system should make it possible to reduce the size or eliminate ship control surfaces entirely, resulting in a small reduction of total drag and increase of ship speed.

## II. THE NEW CONCEPT

The new concept of ship directional control is based on the propulsion system, Sheets (1978), which consists of a hydraulic transmission located outside the ship's hull. The transmission is of the axial flow type having both an axial flow pump and axial flow turbine. It is an open system using seawater as a transmission fluid. The propulsive thrust is divided between the propeller and the fluid discharge from the transmission turbine. By properly selecting pump and turbine configurations, the transmission ratio can be varied within wide limits. A reversing mechanism is incorporated in the transmission eliminating the need for the provision of conventional thrust reversing system.

The water discharge from the transmission turbine will be used for ship control by deflecting it in a predetermined direction. This is accomplished by means of a set of movable hydrofoils installed in the discharge duct. By deflecting the turbine discharge water in the appropriate direction, the action of the rudder and/or control surfaces can be supplemented or control surfaces can be elimianted. This control system can provide a wide range of thrust forces and directions. By adjusting the pump vanes, the ratio of flow energy going to the jet through the transmission can be increased compared to the energy transmitted to the propeller. Thus, very large amounts of power are available for ship control, if needed. This system

is shown in Figure 1.

The proposed control system in its simplest form will provide flow vectors in a single plane and thus will replace the rudder of the ship. However, there will be significant changes compared to the normal rudder action. More specifically, very large forces of directive thrust will be available at low and zero ship speed. At high speed, the angle and amount of the flow thrust vector can be adjusted to meet requirements. In the above described version, the control system consists of a simple actuator controlling the discharge angle of the vanes.

A second version of the control system is shown in Figure 1, and it can provide the same flow directivity of the vanes, but in addition, it will provide for the rotation of the entire vane system, thus giving a two axis flow control and associated thrust force vector. Such a system will permit both steering and diving control for submarines. On surface ships, this system will permit corrections in the ballast system of the ship or to correct the ship to an even keel in case of uneven load distribution.

The new concept of ship control provides for large directive thrusts at very low speeds, thus greatly improving maneuverability in harbors and in docking operations. For special ships such as hydrofoil or surface effect ships, the proposed control system could provide bow thruster action by simply connecting the forward water jet thruster through a pipe and control valve to the high pressure section of the hydraulic transmission. This is shown in Figure 2.

The proposed control system can be designed to be substantially more efficient than the standard one using control surfaces. This will be accomplished by operating the propulsion system in such a mode that, at steady state conditions requiring no ship control action, the water flow through the turbine discharge section is at low velocity and low rate of flow, since the thrust from the turbine discharge provides only a small percentage of the total thrust. The majority of the thrust comes from the propeller driven by the hydraulic transmission. For maximum ship control, however, the adjustable vanes in the transmission pump can be controlled so that a much larger flow can go through the transmission. The thrust from the propeller becomes then relatively smaller, and the thrust from the transmission turbine discharge becomes larger. Thus, high water velocity exists in the ship control section only when control is required. In case ship control is not required, the water velocity is low and so is the corresponding drag or power loss due to the ship control section.

An example of the ship control system is shown in Figure 1. The movement of the flow direction device will be accomplished through servos with the necessary controls and displays inside the ship. Ship control is achieved through the vane discharge control unit (A) which has the capability of directing the turbine discharge flow by changing the angle of the airfoil vanes (B) housed in the discharge fhroud. Although the unit as shown is designed for vanes to have angular movement in only

one plane, 360 degree controllability could be built in by rotating the entire discharge shroud. Both angular vane displacement and shroud rotation are controlled by a single hydraulic motor (C). This motor drives a shaft (D) controlled by a hydraulic ram (E) which engages a sliding fork (F) running on the control shaft. The control shaft can slide inside the hydraulic motor drive spline and engage either the rack which controls vane angle or the hub of the discharge shroud for rotational control. The hydraulic lines run through the stator housing and into the ship via passages in the exit and inlet guide vanes. The discharge shroud assembly is held rigid by four or more fixed vanes (G) fastened to the central shroud hub which is supported by the stator body.

The above described control system is just one of many possible configurations to implement the control system. It is noted that the new propulsion and control system has a special transmission turbine where the rotating turbine blades are structually connected to a cylinder which is in the hub of the propeller. The stationary member of the transmission turbine is on the inside, and it provides ample space for the control devices to actuate the vane discharge control unit.

By studying the proposed control system for ship control, it will be evident that large savings in space and cost are possible due to the reduction and/or omission of existing control surfaces. It may be possible that the new propulsion and control system will result in a reduction in total length and displacement.

The new ship control system can also be used in connection with the new ship propulsion system using contra rotating propellers and associated hydraulic transmissions. It is noted that for very long and large ships, the forward thruster could be designed by using a separate electric drive and propeller. The performance of the new ship control system will be quite similar to using Voith-Schneider propellers which combine propulsion and steering. It may be used not only for ships but for drilling rigs in similar applications where station keeping is as important as forward speed.

## III. CONCLUSIONS

The new ship directional control system offers added advantage for any application where the new propulsion system with the hydraulic transmission is used. This report presents only an overview of potential advantages and uses. The ship control system should be studied in more detail, and it may be suggested that a complete analysis be made for a specific case. From this preliminary analysis, it is believed that the new control system offers an opportunity for added improvements in total ship performance.

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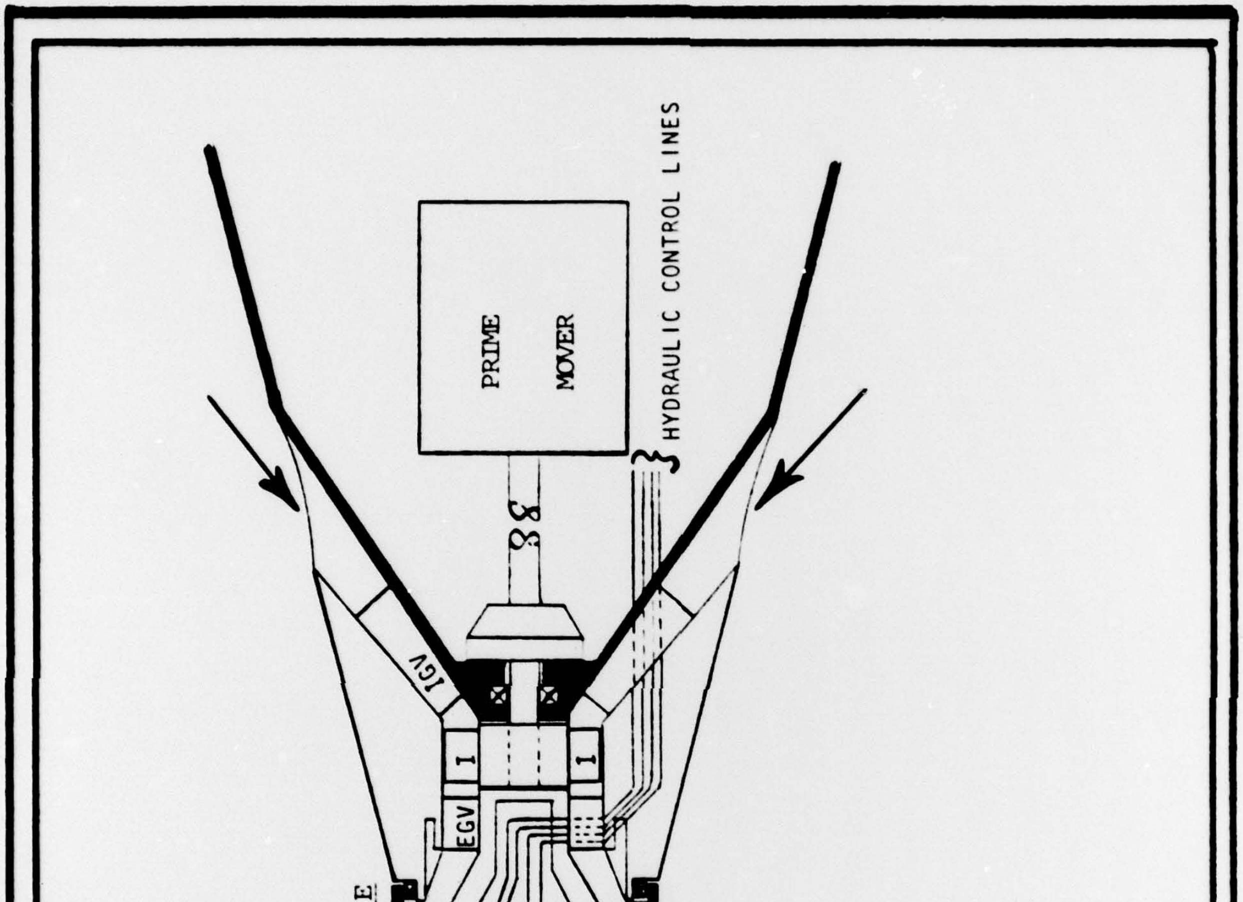
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Figure 1

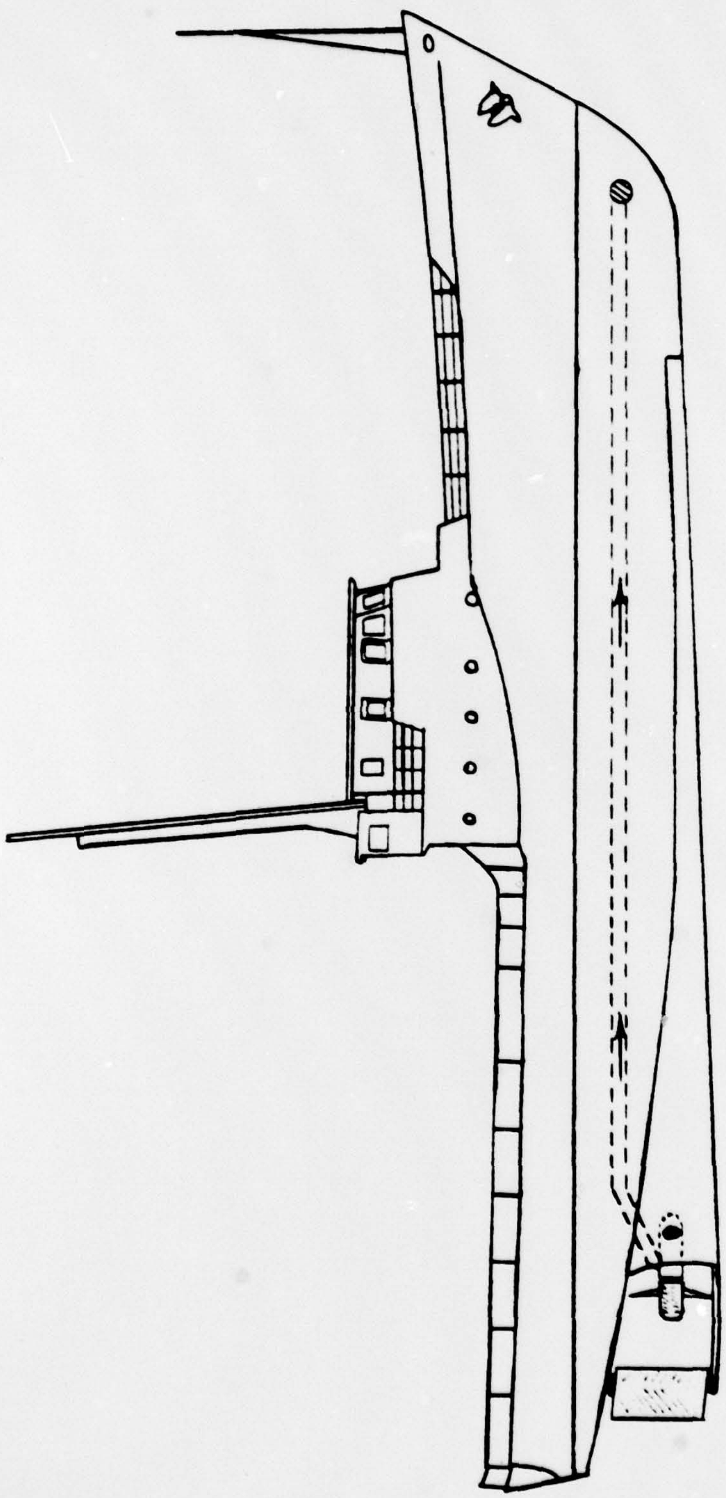

Figure 2